Time Course of Event-related MR Signal Enhancement in Visual and Motor Cortex.

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INTRODUCTION:

Echo-planar imaging of event-related changes in blood oxygenation may provide an exceptional, non-invasive technique for studying brain function in human subjects. Using high speed imaging techniques, it may be possible to record the time course of brain activity while the subject performs a task or receives sensory stimulation. However, the MR signal imaged by this technique reflects alterations in local levels of deoxyhemoglobin (dHB) which then indirectly reflects changes in cerebral activity[1,2]. As a result, it is not clear how rapidly the MR signal can change in response to cerebral activation. Consequently, we have studied the time course of changes in dHB in visual and motor cortex in response to a flashing checkerboard stimulus that also acted as a signal for the subject to initiate finger tapping.

METHODS:

Imaging was performed on a standard clinical GE 1.5 Tesla Signa system using a 30.5 cm i.d. three-axis local gradient coil. A blipped, gradient-echo EPI pulse sequence having an initial pi/2 pulse and an effective TE of 40 ms, (kx,ky)=(0,0), was employed. Data acquisition time was 40 ms to acquire a 64 X 64 image. FOV was 24 cm. with a slice thickness of 15 mm. A series of 75 sequential images of the same plane in the brain was obtained using an inter-scan delay (TR) of 1 sec. Sync pulses generated by the scanner coincident with the 25th and 50th scans were used to trigger onset and cessation of a 32^0 red-black checkerboard pattern flickering at 8 Hz. Alternate stimulus series were delayed 0 or 0.5 sec relative to the sync pulses and each series was presented 12 times. The resulting scan data were combined to yield a composite series with an effective time between scans of 0.5 sec. Mean signal amplitude versus time was graphed for selected single voxel (3.25 X 3.25 X 15 mm) images showing the largest signal change.

RESULTS:

Figure 1 illustrates the time course of normalized signal intensity for calcarine visual cortex and precentral motor cortex of the same subject. Motor cortex response magnitude was 2 times greater than visual cortex response (4.5% vs 2.2% change). Consequently, both curves were scaled to a range of 0-1 to facilitate comparison of transient response phases. The rise-time from stimulus onset to 90% of peak was 5 sec for motor cortex versus 8 sec for visual cortex. In contrast, the fall-time from stimulus cessation to within 10% of baseline was 9 sec for both cortical areas. Rise and fall times for visual cortex in a second subject were similar: rise 7.5 sec, fall 10.5 sec. (Motor cortex response not recorded in second subject.)

Though difficult to measure accurately, the delay from stimulus onset to the time at which the signal first departed from baseline was similar for both cortical areas and was approximately 2-3 sec. The delay from stimulus cessation to the beginning of a fall in signal intensity was longer, 3-4 sec.

CONCLUSIONS:

These results show that local changes in dHB levels following cerebral activation are highly consistent but relatively slow. In contrast, more direct measures of cerebral function often have a significantly faster time course. Single cell responses in primary visual cortex typically begin within 40 msec of stimulus onset and electrical potentials measured from the scalp have typical latencies of 50-100 msec. Nevertheless, the consistency of the MR signal permits resolution of time differences between cortical areas as small as 2-3 seconds. Thus, this technique may be capable of resolving some temporal features of complex cognitive or performance tasks involving extended cerebral activation.

The somewhat surprising finding that the onset of response in motor cortex is faster than in visual cortex does not necessarily indicate that the underlying neural events are inherently faster. Rather, the difference may reflect stronger activation of motor cortex as is suggested by the two-fold greater signal relative to visual cortex that was observed in the data before normalization.

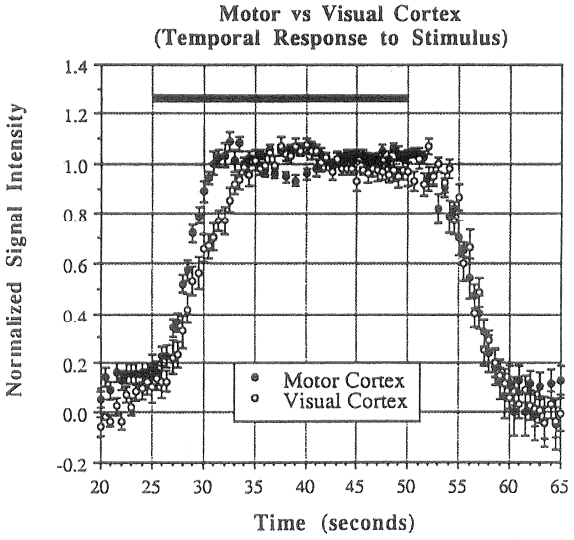

Fig. 1
(Solid bar indicates duration of flashing checkerboard)

REFERENCES:

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